

PATENT DUCTUS ARTERIOSUS*

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I N the past fourteen years since Robert E. Gross¹ performed the first successful operation for occlusion of a patent ductus arteriosus the surgical correction of this congenital anomaly has been well established as one that can be accomplished with a low mortality and excellent results. Shapiro and Johnson in 1947² reported 626 collected cases of patent ductus arteriosus in which operative repair had been carried out by forty-six different surgeons. In 525 uninfected cases in this series the mortality rate was 4.9 per cent. Gross³ has recently reported an overall mortality rate of 2.1 per cent in 412 consecutive cases. In those cases without symptoms prior to operation Gross states that the mortality rate was less than 0.5 per cent.

After employing various techniques of ligation "in continuity" in his first forty-three cases Gross abandoned this method because of a disturbingly high incidence of recanalization. In 1944 Gross described a technique of dividing the ductus and closing the divided ends which he has used since that time and which has been adopted by many surgeons. In the hands of Dr. Gross and his associates this method has proved quite successful and they report no deaths from hemorrhage secondary to division of the ductus. However, some surgeons were of the opinion that division and closure of the ductus was an unnecessarily hazardous procedure from the standpoint of possible uncontrollable hemorrhage. In 1946 Dr. Alfred Blalock⁴ described a suture-ligature technique for obliteration of the patent ductus without division. Scott⁵ has reported 161 cases of closure of the patent ductus using this suture-ligature technique without a single incidence of recanalization and with two deaths. At New York Hospital we have favored the latter course of action. Thirty-six patients with patent ductus arteriosus have been operated upon and thirty-four have had obliteration of the ductus using a modification of the Blalock suture-ligature technique. There have been no deaths in this relatively small series.

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Diagnosis: The diagnosis of patent ductus arteriosus rests almost completely on the finding of the typical murmur. In about 95 per cent of patients with a patent ductus this finding will suffice. The murmur is continuous with systolic accentuation and is best heard in the area under the clavicle and to the left of the sternum. Occasionally it is loudest in the third left interspace. Although the amplitude may vary from quite soft to very loud the murmur has a turbulent quality which is most distinctive. The murmur is often best heard with the patient supine and the diastolic component may be more audible during held expiration. The systolic component is often audible to the apex and may also be heard over the posterior chest.

Once the characteristic murmur is detected further clinical observations are directed not so much towards finding additional data to reinforce the diagnosis as to discovering features which will either cast doubt on the diagnosis or lead to the discovery of associated anomalies. It is only in those patients who then become suspect of having another type of anomaly, e.g., aortic septal defect or ventricular septal defect with aortic insufficiency or an associated anomaly, e.g., septal defects, pulmonic stenosis, etc., that cardiac catheterization or other studies are deemed advisable. The additional data helps in a decision as to the advisability of surgery and in anticipating the likelihood of residual cardiac abnormality.

The presence of cyanosis at rest or after exercise indicates the need for further study even with the finding of a most characteristic murmur. Chest deformity suggestive of either right or left ventricular enlargement or both or of increased pulmonary blood flow (grooves similar to Harrison's grooves in rickets) may be seen with a large shunt present early in life but is unusual in children and should lead to further studies. A very wide pulse pressure especially with a low diastolic pressure is probably more common with aortic septal defect or aortic insufficiency. The electrocardiogram is particularly useful in arousing suspicion since in almost all patients with patent ductus as the sole anomaly the electrocardiogram is quite normal with no axis deviation and only occasional evidence of moderate left ventricular enlargement in the V leads. Fluoroscopy is of help in detecting other lesions for in most patients with patent ductus arteriosus the silhouette is quite normal or may show some degree of left or right ventricular enlargement or both. Intrinsic pulsations of the pulmonary artery branches are often not seen or are of

modest degree. Marked hilar dance or aortic pulsation is uncommon except in patients with a very large ductus.

The lesions which mimic patent ductus arteriosus most closely are aortic septal defect and ventricular septal defect with aortic insufficiency. Both conditions often give rise to a greater degree of cardiac hypertrophy, wider pulse pressure, marked hilar dance and aortic pulsation and a less characteristic murmur.

The diagnosis of patent ductus arteriosus in the presence of a systolic murmur only is possible but in most instances confirmation has been sought by means of angiocardiography, retrograde aortogram, or cardiac catheterization. It is well known that a patent ductus arteriosus may be associated with a systolic murmur only during infancy and early childhood, during heart failure, with reversal of flow and with a markedly small caliber ductus. In all but the last of these the level of pulmonary artery pressure is apparently the most important single factor. Reversal of flow is most easily detected by the presence of cyanosis and clubbing of the toes in contrast to normal appearing fingers.⁶ Improvement of heart failure may reestablish the continuous murmur. During infancy the need for accurate diagnosis may be most urgent if the shunt is very large and leads to marked cardiac hypertrophy with failure.⁷

Case Material: Females predominated over males, there being twenty-two females (61 per cent) and fourteen males (39 per cent). Most of the patients were children or adolescents. One half were in the age group between four and seven years. Only six were over twenty years, the oldest being forty-one years. The youngest was four years. There was no retardation of growth in twenty-two patients, but fourteen are recorded as having been "thin," "underweight" or "small for age." Nine children were completely asymptomatic. The commonest symptom encountered in the children was frequent upper respiratory infections and three had suffered one or more attacks of pneumonia. Only a few children had dyspnea on exertion. In the older age groups dyspnea, palpitations, pain in the chest, easy fatigue, and "lack of pep" appeared as more prominent symptoms.

Twenty-nine patients had a palpable thrill. In thirty-four (94 per cent) there was a typical machinery murmur heard best in the pulmonic area. The pulse pressure exceeded 40 mm. in twenty-seven patients. One patient with subacute bacterial endocarditis was subjected to operation following a four month course of penicillin therapy.

Operative Technique: A left anterior approach has been used. In the first eighteen cases the chest was entered through the left third interspace but subsequently the third rib has been resected in order to secure more adequate exposure. The ductus has been identified by tracing the vagus nerve down to the point where the recurrent laryngeal nerve is given off and curves upward beneath the ductus. After dissecting the ductus free from the surrounding areolar tissue, the ductus has been exposed completely from the aorta to the pulmonary artery. The average ductus in our experience measured 6 to 8 mm. in diameter and in most cases the length exceeded the diameter by 2 to 3 mm. The effect of interruption of flow through the ductus was tested by temporary occlusion for a period of three to five minutes. In general this has produced a narrowing of the pulse pressure, effected by a rise in the diastolic pressure with no change or only slight increase in the systolic pressure. Frequently there has been a slowing of the heart rate with occlusion. In the uncomplicated cases temporary occlusion produced no changes in the vital signs which contraindicated permanent closure of the ductus.

In the first two cases the ductus was ligated with umbilical tape with medium silk ligatures being placed on either side of the tape. In subsequent cases ligatures of No. 4 braided silk have been placed first at the aortic end and then at the pulmonary artery end of the ductus. In placing these ligatures care is taken to tie them just tightly enough to stop the flow of blood. There is a danger here of shearing the ductus off from the larger vessels. Two transfixion sutures of No. 00 cotton have been placed through the ductus at equal distances between the braided silk ligatures. Closure of the chest has been carried out without drainage. Although blood is always held in readiness, transfusion has seldom proved necessary.

Postoperative Course and Complications: The earlier patients were kept in an oxygen tent for the first twenty-four to thirty-six hours following operation but recently we have not used oxygen routinely. Penicillin usually has been started one day prior to operation and continued five to six days after operation. By the fourth or fifth day the patients are up and walking. The majority are ready for discharge by their eighth or ninth postoperative day. Moderate elevation of the blood pressure is often noted during the early postoperative period. This falls slowly and stabilizes by the time of discharge with

the diastolic pressure remaining 10 to 20 mm. higher than the pre-operative level.

Serial x-rays of the chest have revealed a variable degree of pleural effusion. In most cases this has resorbed spontaneously and thoracentesis rarely has been done. Wound infection occurred in one instance. Paralysis of the left phrenic nerve was discovered postoperatively in one case. This was temporary and the left diaphragm moved normally three months following operation. One wound had to be reopened for removal of a catheter tip which had broken off when the catheter was withdrawn at the end of the procedure. There were no cases of laryngeal nerve palsy.

Results: In fourteen cases there were no murmurs following operation. In four cases a soft systolic murmur was heard in the pulmonic area during the immediate postoperative period. Within three to four months these murmurs had faded away and could no longer be detected. Thirteen patients had systolic murmurs in the pulmonic area immediately following operation which have persisted during the follow-up period. In two cases no murmur was heard during the period of hospitalization but a persistent systolic murmur was noted on subsequent visits to the clinic.

There is evidence of recanalization in one instance. This patient was a twelve year old boy whose ductus measured 11 mm. in diameter. The operation and postoperative course were uneventful and no murmurs were heard at the time of discharge. However, three weeks later a systolic and a diastolic murmur were detected. The murmurs have increased in intensity to a continuous machinery murmur. Cardiac catheterization studies done ten months following operation indicate the presence of a patent ductus with a left to right shunt of 3 liters per minute, approximately one third the volume of that observed preoperatively. Reoperation has been advised but thus far the boy's parents have not consented.

In all cases, save this one, the results are considered to be good. The children, who were for the most part without symptoms initially, are leading perfectly normal lives. In the older age group there has been a varying degree of improvement in the symptomatology. Most have shown some improvement, but in those patients in their late twenties or thirties in whom the symptoms were of fairly long standing the improvement has been less striking.

DISCUSSION

The direction of blood flow through the patent ductus arteriosus is determined by the blood pressure gradient between the pulmonary artery and the aorta. In prenatal life the flow is from the pulmonary artery to the aorta. At birth the pressures equalize and there is little flow through the ductus. As the infant grows older the systemic arterial pressure gradually exceeds the pulmonary arterial pressure so that in the failure of the ductus to close spontaneously the flow is from the aorta to the pulmonary artery. In the presence of a large ductus and with advancing age the pulmonary arterial pressure may again exceed aortic pressure; a so-called "reversal of flow" occurs with blood passing from the pulmonary artery to the aorta. The elevated pulmonary arterial pressure results from increased pulmonary arteriolar resistance. Lung biopsies in such cases have shown pulmonary arteriolar sclerosis. The exact cause of this sclerosis is not known; increased blood flow and advancing age have been postulated as possible factors.

In our series two cases of reversal of flow through the patent ductus were encountered. One was a twenty-seven year old female, the other a thirty-seven year old male. Both complained of progressive dyspnea and easy fatigue. Although systolic and diastolic murmurs were present in each case, they were not the typical machinery murmurs. Both had polycythemia, and cyanosis involving only the lower extremities and toe nails, the male showing clubbing of the toes. Arterial oxyhemoglobin saturation determinations were normal in the brachial artery and markedly decreased in the femoral artery in both patients. Angiocardiography and cardiac catheterization studies confirmed the diagnosis. Both patients were explored with the intention of dividing the ductus. In the case of the female the ductus measured 2.5 cm. in diameter and 1.5 cm. in length. Repeated efforts to dissect out the ductus and get around it posteriorly resulted in such a degree of hemorrhage that the region was packed with gel-foam and the procedure abandoned. This patient recovered from the operation, but has shown signs of progressive heart failure.

In the male patient an even larger ductus measuring 4 cm. in diameter was found. During the course of dissecting out the ductus the blood pressure fell to 60 systolic. With temporary occlusion of the ductus blood pressure and pulse became unobtainable. Occlusion was repeated

several times with the same result. Certainly permanent interruption of flow through the ductus could not be carried out at that time. In view of the fact that the patient was already in shock at the time of occlusion of the ductus a second attempt at division is being considered. It is also possible that there may be some yet undetected anomaly of the ascending aorta so that the patent ductus is a necessary channel.

The closure of a large patent ductus with reversal of flow is indeed a difficult and hazardous procedure. Aside from the technical difficulties it may be that in many instances the closure of the ductus under such circumstances is incompatible with life. This is an additional argument in favor of early operation when the risk is slight and the results excellent.

SUMMARY

At New York Hospital thirty-six patients with patent ductus arteriosus have been operated on with closure of the ductus in thirty-four cases using the suture-ligature technique. The diagnosis may be established on the basis of a typical machinery murmur which was present in 94 per cent of cases. There were three complications and no deaths in this series. Two patients with reversal of flow in a large ductus were explored but permanent interruption of flow through the ductus was not carried out.

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